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PATENT

Docket No. 1232-4651

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**UTILITY APPLICATION AND APPLICATION FEE TRANSMITTAL (1.53(b))**

COMMISSIONER FOR PATENTS  
Box Patent Application  
Washington, D.C. 20231



Sir:

Transmitted herewith for filing is the patent application of

Named Inventor(s) and  
Address(es): Katsumi KUREMATSU, 409-15, Matoi, Hiratsuka-shi, Kanagawa-ken, Japan

For: PROJECTION TYPE DISPLAY APPARATUS  
Enclosed are:

☒ 12 page(s) of specification, 1 page(s) of Abstract, 3 page(s) of claims

☒ 6 sheets of drawing ☒ formal ☐ informal

☐      Page(s) of Declaration and Power of Attorney

- ☐ Unsigned
- ☐ Newly Executed
- ☐ Copy from prior application

☐ Deletion of inventors including Signed Statement under 37 C.F.R. § 1.63(d)(2)

☒ Incorporation by Reference: The entire disclosure of the priority application(s) identified below, is considered as being part of the disclosure of the accompanying application and is incorporated herein by reference.

☐ Microfiche Computer Program (Appendix)

☐      page(s) of Sequence Listing

- ☐ computer readable disk containing Sequence Listing
- ☐ Statement under 37 C.F.R. § 1.821(f) that computer and paper copies of the Sequence Listing are the same

☒ Claim for Priority Japanese Application No 11-289465 filed 10/12/99

☐ Certified copy of Priority Document(s)

09680770 100600

- ☐ English translation documents
- ☐ Information Disclosure Statement
- ☐ Copy of 1 Cited reference
- ☐ Copy of PTO-1449 filed in parent application serial No. \_\_\_\_\_.
- ☐ Preliminary Amendment
- ☒ Return receipt postcard (MPEP 503)
- ☐ Assignment Papers (assignment cover sheet and assignment documents)
  - ☐ A check in the amount of \$40.00 for recording the Assignment.
  - ☐ Assignment papers filed in parent application Serial No. \_\_\_\_\_.
  - ☐ Certification of chain of title pursuant to 37 C.F.R. § 3.73(b).
- ☐ This is a ☐ continuation ☐ divisional ☐ continuation-in-part (C-I-P) of prior application serial no. \_\_\_\_\_.
- ☐ Cancel in this application original claims \_\_\_\_\_ of the parent application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ A preliminary Amendment is enclosed. (Claims added by this Amendment have been properly numbered consecutively beginning with the number following the highest numbered original claim in the prior application.
- ☐ The status of the parent application is as follows:
  - ☐ A Petition For Extension of Time and a Fee therefor has been or is being filed in the parent application to extend the term for action in the parent application until \_\_\_\_\_.
  - ☐ A copy of the Petition for Extension of Time in the co-pending parent application is attached.
  - ☐ No Petition For Extension of Time and Fee therefor are necessary in the co-pending parent application.
- ☐ Please abandon the parent application at a time while the parent application is pending or at a time when the petition for extension of time in that application is granted and while this application is pending has been granted a filing date, so as to make this application co-pending.
- ☐ Transfer the drawing(s) from the patent application to this application.
- ☐ Amend the specification by inserting before the first line the sentence:  
This is a ☐ continuation ☐ divisional ☐ continuation-in-part of co-pending application Serial No. \_\_\_\_\_ filed \_\_\_\_\_.

## I. CALCULATION OF APPLICATION FEE (For Other Than A Small Entity)

	Number Filed		Number Extra	Rate	Basic Fee \$ 710.00
Total Claims	12	-20=	0	x\$18.00	\$ 0
Independent Claims	1	- 3=	0	x80.00	\$ 0
Multiple Dependent Claims	<input type="checkbox"/> yes <input checked="" type="checkbox"/> no		Additional Fee = Add'l Fee = 270.00		NONE \$ 0

Total: \$710.00

- ☐ A statement claiming small entity status is attached or has been filed in the above-identified parent application and its benefit under 37 C.F.R. § 1.28(a) is hereby claimed. Reduced fees under 37 C.F.R. § 1.9(F) (50% of total) paid herewith \$ \_\_\_\_\_.
- ☒ A check in the amount of \$710.00 for payment of the application filing fees is attached.
- ☐ Charge Fee(s) to Deposit Account No. 13-4500. Order No. \_\_\_\_\_. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.
- ☒ The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500, Order No. 1232-4651. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

Respectfully submitted,

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Serial No. : To Be Assigned Examiner: To Be Assigned  
Filed : October 6, 2000 (Herewith) Group Art Unit: TBA  
For : PROJECTION TYPE DISPLAY APPARATUS

EXPRESS MAIL CERTIFICATE

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**EF024393505 US**

Date of Deposit October 6, 2000

I hereby certify that the following attached paper(s) and/or fee  
Application Fee Transmittal (in duplicate); 12 pp. of specs., 1 page of abstract, 3 pp claims (12 TOTAL  
claims); 6 Sheets of Formal Drawings (Figs. 1-6); Check in the amount of \$710.00 (filing fee); and return  
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is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37  
C.F.R. §1.10 on the date indicated above and is addressed to the Commissioner for Patents, Box New Applications,  
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Typed or printed name of person  
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## PROJECTION TYPE DISPLAY APPARATUS

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           This invention relates to a projection type display apparatus, and particularly to a projection type display apparatus attaining a great improvement in light utilizing efficiency or the thinning of the apparatus in an oblique projection system.

#### 10   Related Background Art

          An apparatus of this kind is disclosed, for example, in Japanese Patent No. 2893877. The construction of a basic optical system according to this example of the prior art is shown in Fig. 6 of the  
15   accompanying drawings. In this example of the prior art, a trapezoidal intermediate image is formed on a reflecting mirror 49, and it is obliquely projected onto a screen 53 by a projection lens 40. As regards the trapezoid rate of this intermediate image, the  
20   trapezoid rate of an inverted trapezoid is set so as to just cancel trapezoid distortion created by the oblique projection onto the screen 53.

          In the above-described example of the prior art, however, the trapezoid distortion is cancelled and  
25   corrected, but the principal ray of reflected light reflected by the reflecting mirror 49 on which the intermediate image is formed does not coincide with the

optical axis of the projection lens 40 at all and therefore, as shown in Fig. 6, only the other divergent light beam than the principal ray passes to the projection lens 40. Therefore, the quantity of light  
5 which can be utilized is slight, and this example of the prior art has a problem in that light utilizing efficiency becomes very bad.

#### SUMMARY OF THE INVENTION

10 It is an object of the present invention to solve the above-noted problem peculiar to the prior art and to provide, in a projection optical system for correcting trapezoid distortion occurring to an intermediate image by oblique projection, a super-thin  
15 projection type display apparatus which can achieve a great improvement in light utilizing efficiency and can accomplish the projection of a large image plane.

It is also an object of the present invention to provide a projection type display apparatus which  
20 comprises:

a first projection optical system for obliquely projecting light from an original picture onto a predetermined surface, the first projection optical system forming the intermediate image of the original  
25 picture on or near the predetermined surface;

a second projection optical system for obliquely projecting the light from the predetermined surface

onto a surface for projection and imaging it thereon;  
and

light deflecting means disposed between the first  
projection optical system and the second projection  
5 optical system for deflecting the light emerging from  
the first projection optical system;

wherein the optical axis of the first projection  
optical system is deflected by the light deflecting  
means so as to substantially coincide with the optical  
10 axis of the second projection optical system.

In the foregoing, "near" appearing in "the first  
projection optical system forming the intermediate  
image of the original picture on or near the  
predetermined surface" means a range within which the  
15 intermediate image can be regarded as being formed  
substantially on the predetermined surface, including a  
case where the positions of "the predetermined surface"  
and "the intermediate image" slide a little in  
parallelism to each other, and a case where the two  
20 intersect with each other. That is, it means that when  
an observer disposes a screen or the like on the  
predetermined surface and observes the intermediate  
image of the original picture, the positions of the  
predetermined surface and the intermediate image are  
25 near to each other to such a degree that the  
intermediate image can be observed within a range in  
which a feeling of resolution is sufficiently obtained





substantially vertically disposed reflecting mirrors.

In further aspect of the invention, the projection type display apparatus is of a rear projection type projecting an image from the rear onto the surface for projection.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 generally shows a basic optical system for a thin type rear projection display apparatus according to an embodiment of the present invention.

Fig. 2 shows the cross-sectional construction of the thin type rear projection display apparatus according to the embodiment of the present invention.

Fig. 3 shows the cross-sectional construction of a hologram transmission type diffracting optical element in the embodiment of the present invention.

Fig. 4 shows the cross-sectional construction of a screen for coping with oblique incidence in the embodiment of the present invention.

Fig. 5 shows the plan construction of an eccentric Fresnel screen in the embodiment of the present invention.

Fig. 6 generally shows an optical system for thin type rear projection according to the prior art.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the so-called optical trapezoidal correction

oblique projection optical system as described above,  
for example, a diffracting optical element is utilized  
as a medium for propagating a trapezoidal intermediate  
image, whereby light emerging from the intermediate  
5 image can be directed in the direction of the optical  
axis of a main projection lens (a second projection  
optical system) and further, it becomes possible to  
achieve a great improvement in light utilizing  
efficiency. Also, by providing a plurality of  
10 vertically or substantially vertically disposed plane  
mirrors downstream of the projection lens, it becomes  
possible to achieve super-thinning and large image  
plane in a rear projection display apparatus above all.  
A specific embodiment thereof will be shown below.

15 (Embodiment)

Fig. 1 generally shows a basic optical system for  
a thin type rear projection display apparatus according  
to an embodiment of the present invention. In Fig. 1,  
reference numeral 1 designates a screen for oblique  
20 incidence, reference numeral 2 denotes a main  
projection lens (a second projection optical system),  
reference numeral 3 designates a transmission type  
diffracting optical element which is a light deflecting  
element, reference numeral 4 denotes an auxiliary  
25 projection lens (a first projection optical system),  
reference numeral 5 designates a DMD display device,  
reference numeral 6 denotes a condensing lens,

reference numeral 7 designates a collimator and  
integrator, reference numeral 8 denotes a rotary color  
filter, and reference numeral 9 designates a UHP lamp.  
The reflector of the UHP lamp 9 is of an elliptical  
5 type and therefore, light emerging from this lamp is  
condensed and passes to the rotary color filter 8. The  
rotation of this rotary color filter 8 is synchronized  
with the driving of the DMD display device 5, and  
design is made such that the writing display by each  
10 primary color signal and the color light after passed  
through the rotary color filter 8 coincide in color  
with each other. Next, the color light passed through  
the rotary color filter 8 passes through the collimator  
and integrator 7, whereby the collimation of the light  
15 beam and the prevention of uneven illumination are  
done, and the DMD display device 5 is efficiently  
illuminated through the condensing lens 6.

Only the display reflected light from the DMD  
display device 5 passes through the auxiliary  
20 projection lens 4, and by the imaging action of this  
auxiliary projection lens 4, the intermediate projected  
image thereof is formed on the transmission type  
diffracting optical element 3. The DMD display device  
5 and the transmission type diffracting optical element  
25 3 are tilted relative to the optical axis of the  
auxiliary projection lens, and the tilt angles  $\theta_4$  and  $\theta_3$   
thereof are set in conformity to the so-called

Sheimpflug rule. Accordingly, a trapezoid distorted image is formed on the transmission type diffracting optical element 3, but as in the aforescribed example of the prior art, the trapezoid rate thereof is set so as to just cancel trapezoid distortion caused by an oblique projection system onto the screen which will be described later.

Now, the transmission type diffracting optical element 3 has the action of refracting a ray of a predetermined angle of incidence by a predetermined angle, and a light beam passing through and emerging from the transmission type diffracting optical element after having formed the intermediate image has its on-axis ray refracted in the direction of the optical axis of the main projection lens 2, i.e., the direction in which this emergent light beam enters the pupil of the main projection lens 2, by this refracting action. Fig. 3 shows the cross-sectional construction of the transmission type diffracting optical element. This transmission type diffracting optical element is of a construction in which a gelatin layer 32 is sandwiched between glass plates 31 and 33. The gelatin layer forms a hologram which is a diffracting optical element by laser beam exposure, and any ray angle of refraction is set by the setting of the condition of this laser beam exposure. So, in the hologram element 3 used in this embodiment, the ray angle of refraction thereof is

set so that as previously described, the emergent light beam may be refracted in the direction in which it enters the pupil of the main projection lens 2.

5 The ray of light from the intermediate image emerging in the direction of the optical axis of the main projection lens 2 in this manner is efficiently obliquely projected onto the screen 1 through the main projection lens 2. That is, the intermediate image is enlarged and projected onto the screen by the main  
10 projection lens 2, but a predetermined rectangular image is displayed on the screen by the trapezoid distortion canceling mechanism as previously described. Also, the screen 1 and the light deflecting element 3 are installed while being tilted with each other  
15 relative to the optical axis of the main projection lens 2, and the tilt angles  $\theta_2$  and  $\theta_1$  thereof are also set in conformity to the Sheimpflug rule.

Next, Fig. 2 shows the cross-sectional construction of the rear projection display apparatus  
20 of the present invention contained in a thin type housing by folding the beam of the optical system by mirrors. In Fig. 2, dots-and-dash line indicates the outer configuration of a housing, reference numeral 20 designates a second mirror, and reference numeral 21  
25 denotes a first mirror. Both of these mirrors are plane mirrors, and are vertically disposed. That is, the two mirrors face in a direction in which their

reflecting surfaces face each other, and are disposed parallel to each other. The light beam emerging from the projection lens 2 is first reflected by the first mirror 21 located below the screen, and the reflected  
5 light beam thereof is further reflected forwardly and upwardly by the second mirror 20 located on the upper side of the rear of the apparatus, and illuminates the screen 1 toward a obliquely upward direction. By thus combining the oblique incidence and the turning-back of  
10 the light beam by a plurality of vertically disposed mirrors, the formation of a large image plane rear projection display apparatus of a thin type and good in light utilizing efficiency becomes possible. Incidentally, it is expected that in a display image  
15 plane 9:16 long sideways and having a diagonal of 60", a depth of 30 cm becomes possible.

Also, the screen 1 used in the present embodiment is one for oblique incidence, and the cross-sectional construction thereof is shown in Fig. 4. This screen  
20 is comprised of three members i.e., an eccentric Fresnel lens 13, an eccentric Fresnel lens 12 and a lenticular lens 11 superposed one upon another in succession from the incidence side. The eccentric Fresnel lenses 12 and 13 are entirely the same in  
25 specification. As shown in Fig. 4, the projected light obliquely incident from the back side emerges toward the front over the whole surface by the condensing

effect of these two eccentric Fresnel lenses. Further, at this time, the projected light diverges in a horizontal direction (in Fig. 4, a direction perpendicular to the plane of the drawing sheet) by the lenticular lens 11, and a projected image of uniform brightness is thus observed over a wide field of view from the front looking side.

The plan construction of the eccentric Fresnel lens is shown in Fig. 5. As can be seen from this figure, the eccentric Fresnel lens can be formed by cutting out at a position offset from the center of general concentric circular Fresnel.

Now, the above-described construction of the present embodiment is a specific example of the embodiment, and can be variously arranged. For example, in the present embodiment, the intermediate image is formed on the light deflecting element, but the main purpose of canceling trapezoid distortion can be achieved even if the intermediate image is formed in the air near the light deflecting element. Also, while DMD is used as the display device, this is not restrictive, but a thin type rear projection display apparatus can likewise be constructed even if a reflection type or transmission type liquid crystal display device, an organic EL display device, a display device utilizing an electron beam (e.g. a CRT) or the like is utilized.

Also, as the projection system, use may be made, for example, of a curved surface reflecting mirror or the like instead of a lens, with an auxiliary projection system.

5       Also, if the light deflecting element is constituted by a hologram, not only the light deflecting action but also the light condensing action may be added thereto and a field mirror or lens effect may be imparted thereto, and in this case, the quantity  
10       of light around the projected image can be increased. Further, the light deflecting element is not restricted to a hologram element, but may be a diffracting optical element of other type such as a reflection type or a transmission type, or a linear Fresnel plate of fine  
15       pitch or the like.

With regard also to the screen construction, it is possible to use a diffusing plate instead of the lenticular lens, and hologram plates or hologram sheets instead of the Fresnel lenses.



WHAT IS CLAIMED IS:

1. A projection type display apparatus  
comprising:

5 a first projection optical system for obliquely  
projecting light from an original picture onto a  
predetermined surface, said first projection optical  
system forming the intermediate image of the original  
picture on or near said predetermined surface;

10 a second projection optical system for obliquely  
projecting the light from said predetermined surface  
onto a surface for projection and imaging it thereon;  
and

15 light deflecting means disposed between said first  
projection optical system and said second projection  
optical system for deflecting the light emerging from  
said first projection optical system;

20 wherein the optical axis of said first projection  
optical system is deflected by said light deflecting  
means to substantially coincide with the optical axis  
of said second projection optical system.

2. A projection type display apparatus according  
to Claim 1, wherein said light deflecting means is  
disposed on said predetermined surface.

25

3. A projection type display apparatus according  
to Claim 1, wherein said light deflecting means is

constituted by a transmission type diffracting optical element.

4. A projection type display apparatus according  
5 to Claim 1, wherein said light deflecting means is  
constituted by a reflection type diffracting optical  
element.

5. A projection type display apparatus according  
10 to Claim 1, wherein said light deflecting means is a  
hologram.

6. A projection type display apparatus according  
to Claim 1, wherein said light deflecting means is  
15 disposed at or near the position of said intermediate  
image.

7. A projection type display apparatus according  
to Claim 1, wherein said surface for projection has an  
20 eccentric Fresnel lens.

8. A projection type display apparatus according  
to Claim 1, wherein said surface for projection has a  
plurality of eccentric Fresnel lenses.

25

9. A projection type display apparatus according  
to Claim 1, wherein said surface for projection has a

lenticular lens.

10. A projection type display apparatus according  
to Claim 1, wherein said light deflecting means has the  
5 light deflecting action and the light condensing  
action.

11. A projection type display apparatus according  
to Claim 1, further comprising a plurality of  
10 vertically or substantially vertically disposed  
reflecting mirrors.

12. A projection type display apparatus according  
to Claim 1, which is of a rear projection type  
15 projecting an image from the rear onto the surface for  
projection.

In order to achieve a great improvement in light utilizing efficiency, a projection type display apparatus for obliquely projecting an original image

5        onto a screen includes a first projection optical  
system for projecting light from an original picture  
and forming an intermediate image having trapezoid  
distortion caused therein, a second projection optical  
system for obliquely projecting the light from the  
10       intermediate image onto a surface for projection so as  
to cause converse trapezoid distortion, and re-imaging  
it, and light deflecting element for deflecting the  
optical axis of the first projection optical system so  
that the optical axis of the first projection optical  
15       system deflected by the light deflecting element is  
made to substantially coincide with the optical axis of  
the second projection optical system.

**FIG. 1**

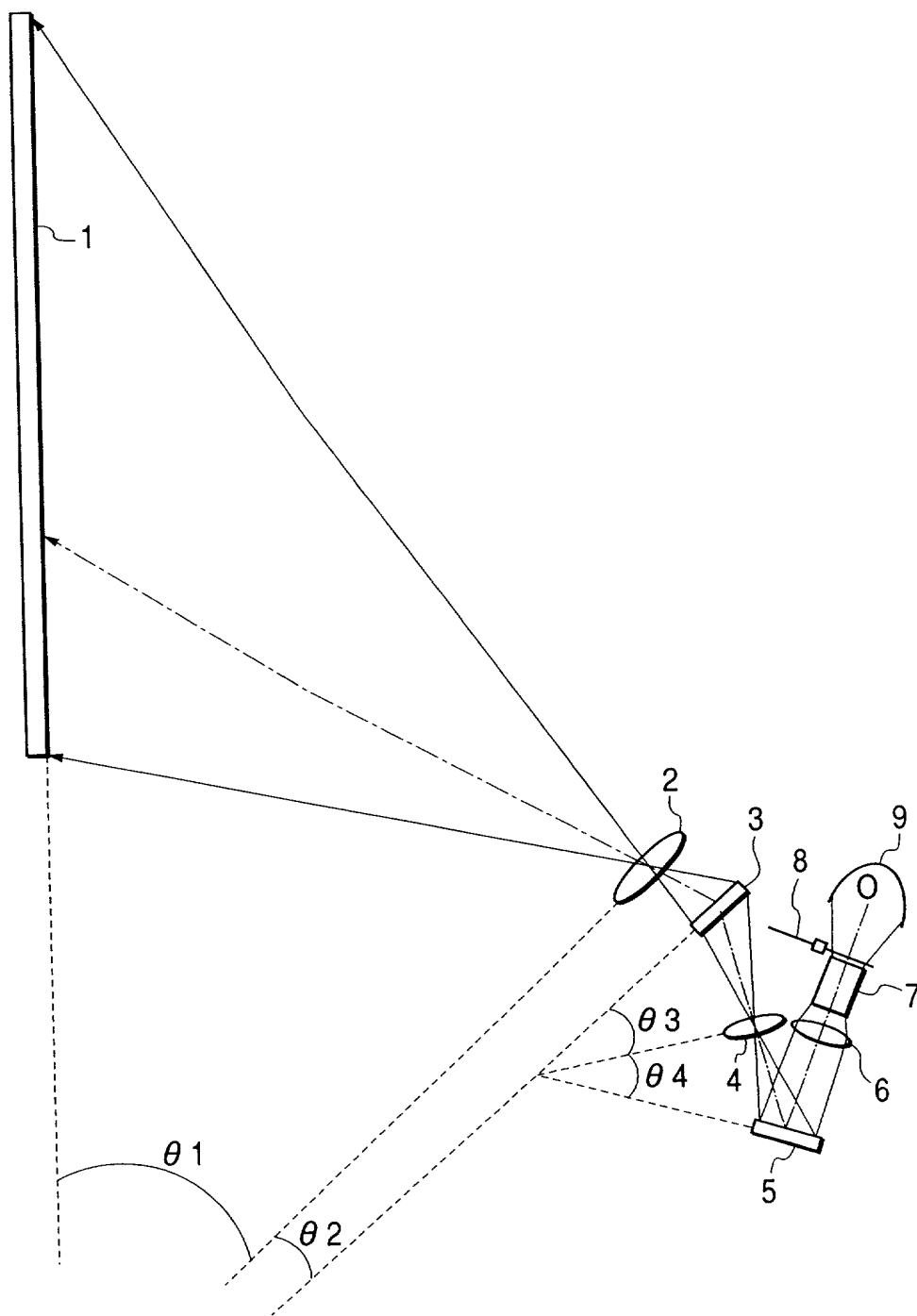
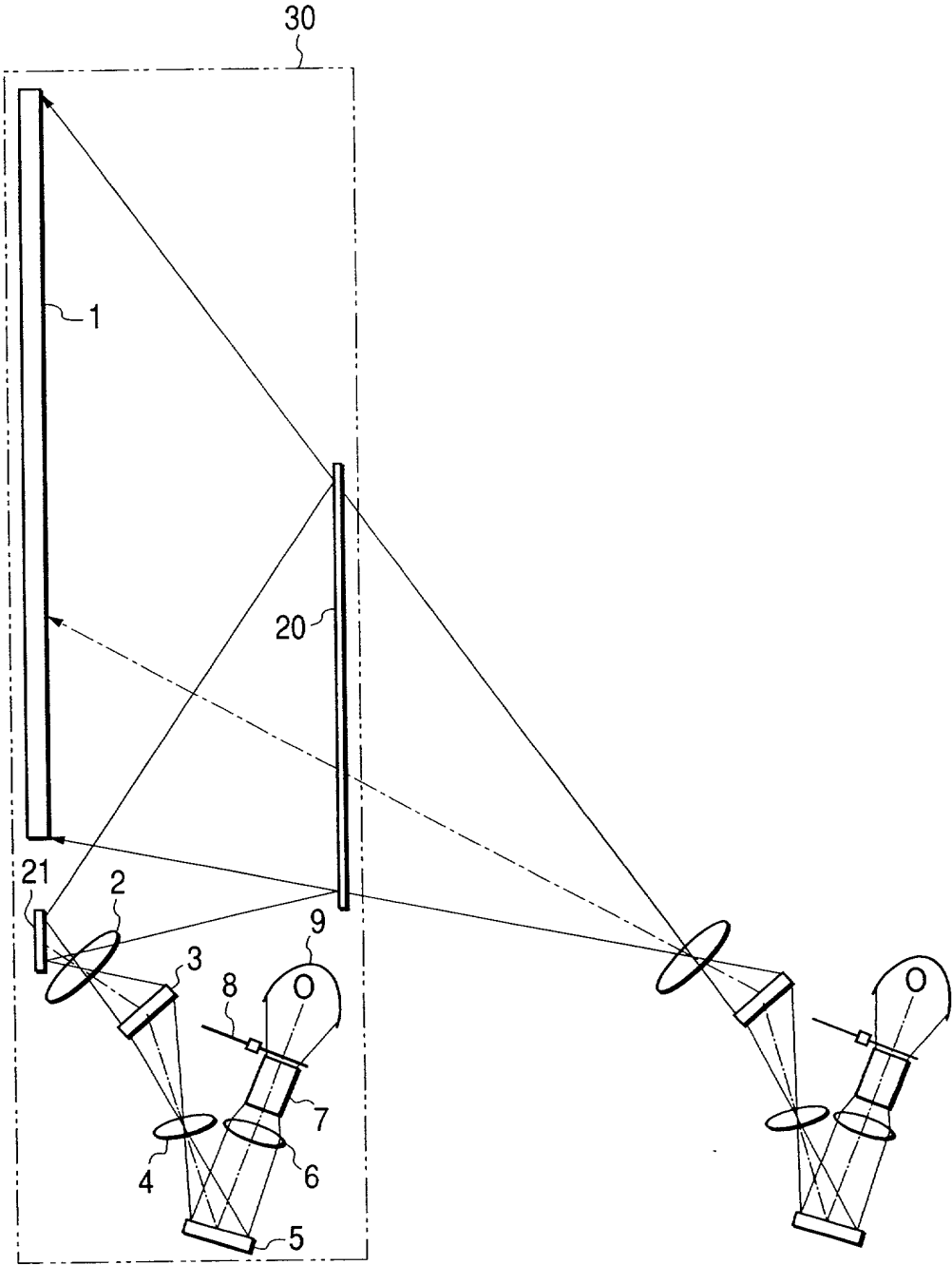
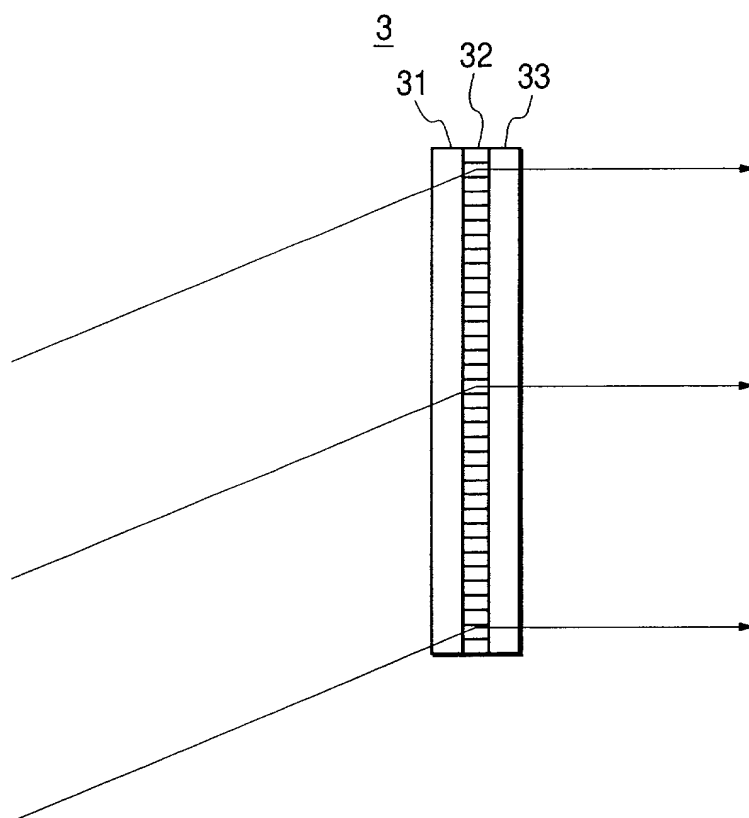
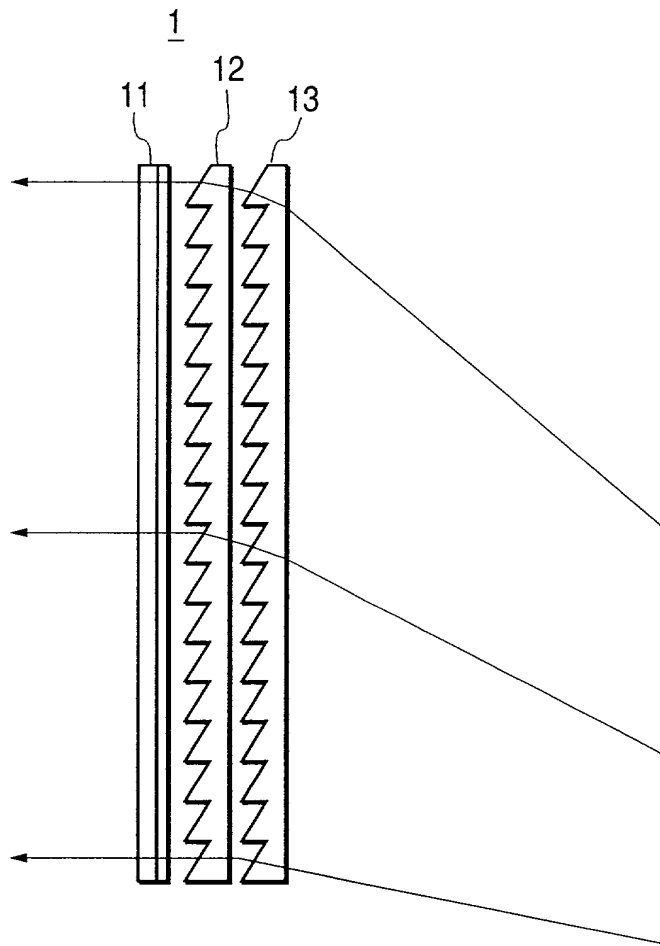


FIG. 2



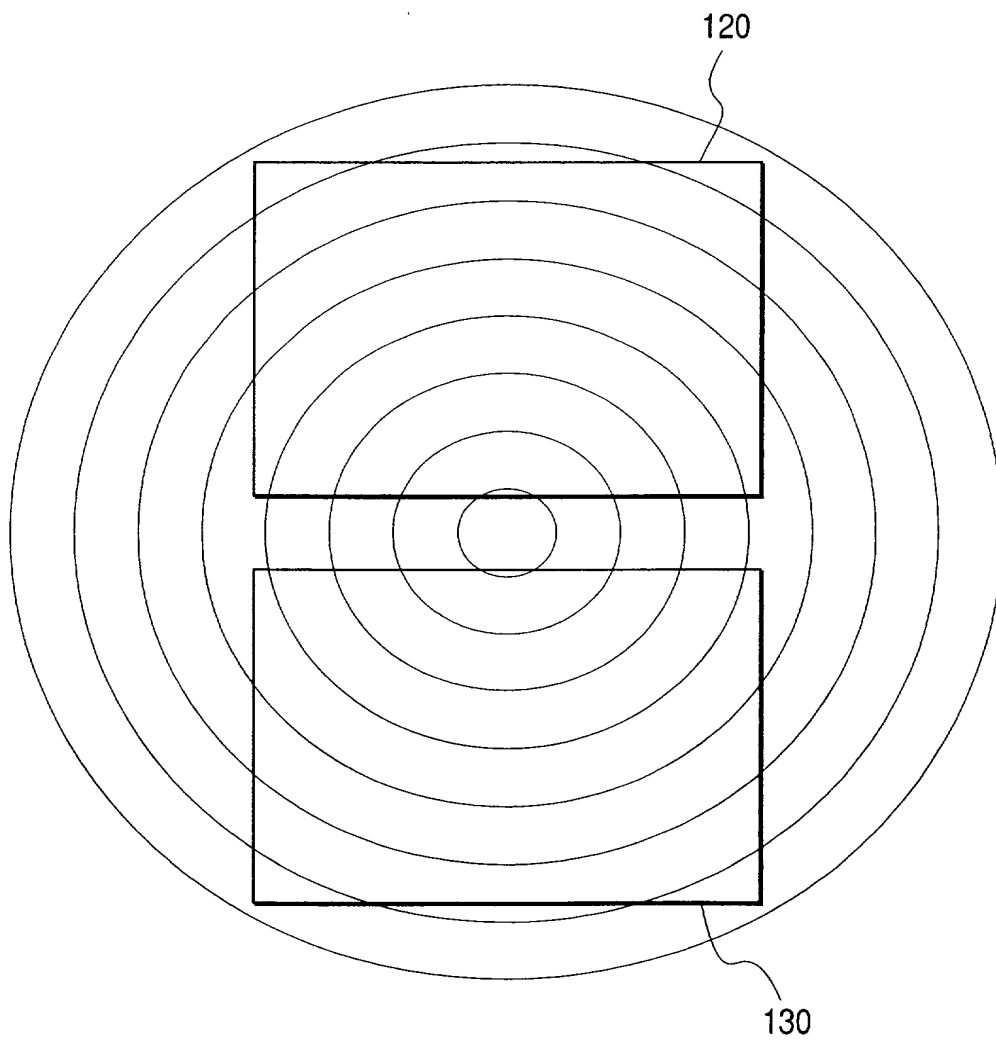
*FIG. 3*



*FIG. 4*



*FIG. 5*



*FIG. 6*